The Distribution of Rents in Supply Chain Industries: The Case of High Oil Corn

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Abstract:

Value-enhanced crops (VEC's) have been the focus of "second-generation" genetically modified (GM) crops. The market power granted by intellectual property rights (IPR) and the use of contractual arrangements in VEC gene and seed production have fostered a move toward tightly-aligned supply chain industries. This paper suggests and tests an analytical methodology for examining a number of issues in tightly-aligned supply chain industries: (1) the distributions of potential monopolistic and monopsonistic rents, (2) choices of licensing intellectual property versus in-house seed production and distribution (3) implications of alternative marketing strategies and elasticities of demand on the magnitudes of rents, and (4) determining impacts on different stages within the supply chain and on substitute commodities. The high-oil corn industry is used as a case study.

Key Words: equilibrium displacement, high-oil corn, mathematical programming, value-enhanced crops

Introduction

The advent and growth of "first-generation" genetically modified (GM) crops, first introduced in 1996, altered the crop production-utilization value chain in many ways. Large companies such as Monsanto, Dupont, Pioneer, and Cargill quickly entered the development of technology and intellectual property relating to GM crops, in some cases with widespread licensing of the intellectual property to seed companies, in other cases by acquiring seed companies. Bt cotton and herbicide-tolerant soybeans are examples of such "first-generation" innovations containing GM input traits which substitute for chemical input usage. Innovators maintain market power of GM seed through intellectual property rights (IPR) and are able to capture additional rents from licensed seed companies and/or farmers. Researchers have evaluated welfare effects of these first-generation GM crops with various monopolistic market structures (2, 2000), (3, 2000), (6, 2000). Little analytical research has been completed addressing the issues raised by development of "second generation" GM crops, referred to as value-enhanced crops (VEC), which contain a value-added component with one or more output characteristic(s), such as increased oil or increased protein. In the case of GM-VEC crops, market power may also be negotiated with other stages of the value chain through contractual arrangements. Our purpose in this paper is to suggest and test an appropriate analytical methodology for examining a number of issues in tightly-aligned supply chain industries. These are:

- The distributions of potential monopolistic and monopsonistic rents in the crop production/utilization value chain.
- Whether to license the intellectual property or have a presence in the seed production and distribution stages.
- The implications of alternative marketing strategies and elasticities of demand on the magnitudes of rents,
- The impacts of these alternative strategies on the monopolistic seed and competitive grain production stages within the supply chain.
- The side-effects of alternative strategies on production, utilization and profitability of substitute commodities.

Due to information limitations of other VEC, we use the high oil corn industry (HOC), a non-GM crop, as a case study.

Review of Literature

The literature of Equilibrium Displacement (ED) modeling goes back to Reuben Buse (1, 1958) who called the approach "total elasticities." Piggott *et al* (7, 1995) presented a similar method and renamed it Equilibrium Displacement (ED) modeling and applied it to assessing the impacts of incremental advertising expenditures. ED models, while easily solved with spreadsheet technology, have a number of limitations for our purposes:

- ED models do not handle cases of monopoly or monopsony without modification.
- Because of constant elasticities of demand, it is conceptually impossible to determine maximum residual rent solutions.
- Expansionary displacements assume no physical constraints to expansion exist, *e.g.* limitations on total cropland or existing production capacity.
- Contractionary displacements, if resulting in more than 100 percent reduction of any activity or process, are *a priori* infeasible because they imply the process in question is operating in reverse in that solution.
- ED Model supply functions are assumed to be downwardly continuous. However, supply functions are truncated where supply price drops below average variable cost.

To overcome these limitations, we adopt a Positive Mathematical Programming (PMP) approach. The literature of PMP is replete with applications but there are only two methodological articles. Howitt (4, 1995) explains a pragmatic method of using dual values of LP model solutions to introduce quadratic terms that assure the model's base period solution matches the base period primal variable levels of the system. Preckel, Harrington and Dubman (8, 2002) extend the Howitt PMP methods to calibrate both the primal and dual levels of the system, calibrating base period prices and quantities in a system of agricultural sector supply and demand relationships.

Equilibrium Displacement Math Programming (EDMP) Models

Following Preckel, Harrington, and Dubman, (8) we formulate the problem as the quadratic programming problem:

Max:	$Z = f'x - \frac{1}{2}\ x'\,\mathrm{H}\,x$				(1)
Subject to:	$\mathrm{A}_{11}x$	$=$	Free	Indicator Accounts,	(1a)
	$\mathrm{A}_{21}x$	$\leq$	b	Technical Constraints	(2)
	$\mathrm{I}_{31}x$	$=$	c	Calibration Constraints	(3)
	x	$\geq$	0	Non-negativity Constraint	(4)

Where:	$\mathrm{A}_{11}, \mathrm{A}_{21}$	$=$	A matrix of Leontief technical requirements of processes
	I_{31}	$=$	An identity matrix of calibration constraints, suspended after calibration
	x	$=$	A vector of optimized variables (which assures that all solutions are feasible and efficient)
	b	$=$	A vector of Right Hand Sides of technical constraints
	c	$=$	A vector of calibration targets to reproduce base equilibrium, suspended after calibration
	f	$=$	Intercepts of supply and demand processes
	H	$=$	Hessian matrix of marginal adjustment costs and demand slopes, assumed to be positive semi-definite

Equation (1a) is necessary because the value of the objective function, Equation (1), is confounded by the values of calibration constraints. Equation (3) is enforced only in the initial calibration solution and suspended thereafter.

We can demonstrate that the EDMP formulation is equivalent to a profit function formulation in both the monopolistic firm and competitive industry cases. Let f(*x*) be a general multi-output multi-input profit function, with *x* containing both inputs (-) and outputs (+), with prices related to quantities, subject to equations (2) and (4). A second order Taylor Series expansion of f(*x*) in the neighborhood of its maximum (*x**) is:

$$f(x) = f(x^*) + \frac{f'(x^*)(x-x^*)}{1!} + \frac{f''(x^*)(x-x^*)^2}{2!} + R \qquad (5)$$

Where R represents the higher order non-linearities of f(*x*). Assuming the base situation to be in equilibrium (a maximum), then $f'(x^*) = 0$. Rearranging terms to matrix notation, the Taylor Series expansion becomes:

$$f(x) = f(x^*) + \tfrac{1}{2}\,(x-x^*)'\,H\,(x-x^*) \qquad (6)$$

By definition, $f''(x^*)$ is the Hessian, $H(x^*)$ and f(x*) is the intercept terms vector, *f,* of the quadratic programming problem. Changing the sign to negative allows H to be specified as positive semi-definite. Hence, in the monopolistic case, the maximand Z is identical to the monopolistic firm's profit function. Both monopolistic and perfectly competitive behavior can be combined for different activities within a single model. Perfectly competitive supply and demand equilibrium is found by maximizing the sum of producers' plus consumers' surpluses. The gradient is the perfectly competitive market price and residual rents are identically equal to zero. In the monopolistic maximum rent solution, found by equating marginal revenue with marginal factor cost, product and factor prices are the points on the respective demand and supply functions that correspond to MR = MFC.

High Oil Corn as a Case Study

The demand for second-generation GM or VEC crops is driven by the quality attributes or characteristics of the particular product. In the U.S., product quality traits accounted for 18 percent of all approved field trials between 1987 and September 2004 with interest peaking in the mid-1990s. In 1994 and 1995, more trials were conducted for product quality than for any other phenotype category. Production of high oil corn (HOC) increased from 170,000 acres in 1995 to just over 1 million acres in 1999.

Farmers and industry must have adequate financial incentives to adopt technologies that may be risky. In the case of HOC, the product price for HOC is equal to that of conventional corn plus a premium based on oil content levels greater than 6.5 percent. Observations have been that there has been slow growth of GM-VEC in general including HOC, which is mostly attributed to the low cost of oil substitutes, such as feed fat (U.S. Grains Council, 2002).
Due to these factors that affect the growth of GM-VEC, it is likely that the demand for the HOC trait is relatively elastic.

Data and Empirical Relationships in the High Oil Corn Industry

HOC is a non-transgenic VEC that can be utilized for animal feed and human consumption. The HOC market is vertically-structured and includes an HOC seed market and an HOC grain market. The HOC seed market includes intellectual property rights (IPR) acquisition and licensed seed companies and can behave as a monopoly due to intellectual property right licensing agreements established by the IPR firm. The value chain begins with the transfer of the innovation or high oil gene from the IPR firm to a licensed seed company, where a technology fee is imposed, the seed company in turn sells high oil seed to growers of HOC. Seed companies then reserve the right to transfer the technology fee to HOC growers.

The 1999 production year was chosen due to the maximum penetration of HOC produced in the U.S. Table 1 shows production data for conventional corn and HOC for 1999. The 1999 market price for conventional corn was $1.82 per bushel, harvested acreage was 70.5 million acres, and average yield per harvested acre was 133.8 bushels of conventional corn. Seed costs for conventional corn are based on the USDA Economic Research Service's costs and returns production data from 1996 to 2001. HOC production for 1999 in the U.S was 1 million acres with an average yield of 129.79 bushels per acre. The market price of $2.02 per bushel for HOC is based on conventional corn plus the average premium of $0.20 per bushel for HOC. HOC seed costs are calculated as the average cost of conventional corn seed per acre plus technology fees of $7.27 per acre, the equivalent of $20 per 80,000-kernel bag. All non-seed input costs were adjusted from conventional corn and HOC yields assuming a 3% yield drag.

Economic Model Structure

Pricing of intellectual property or technology has often reflected a strategy of maximizing market penetration by offering an unlimited supply of the intellectual property and charging a technology fee or royalty to cover sunk development costs. Alternative possible strategies include monopolistic licensing of the intellectual property, wherein the innovator licenses intellectual property narrowly and extracts the rent maximizing license fee, or monopolistic supplying of the product, wherein the innovator monopolistically supplies the product instead of the intellectual property. In Figure 1, monopolistic rents, the upper shaded area, arise because the single seller can extract the price indicated by a point on the demand curve, while only

Table 1: Conventional Corn and High Oil Corn Production Data for 1999

Data Description	Units	Conventional Corn Estimated Values	High Oil Corn Estimated Values
Market Price	\$/Bushel	1.82[a]	2.02[b]
Harvested Acreage	Thousand Acres	70500[a]	1000[c]
Seed Costs	\$/Acre	60.00[d]	60.00[d]
Non-seed Costs	\$/Acre	153.10[a,e]	153.04[a,f]
Average Yield	Bushels/Acre	133.80[a,e]	129.79[g]

[a]USDA - World Agricultural Outlook Board

[b]Market price equals the market price for conventional corn plus the average premium in 1999 of \$0.20 per bushel.

[c]U.S. Grains Council (1999)

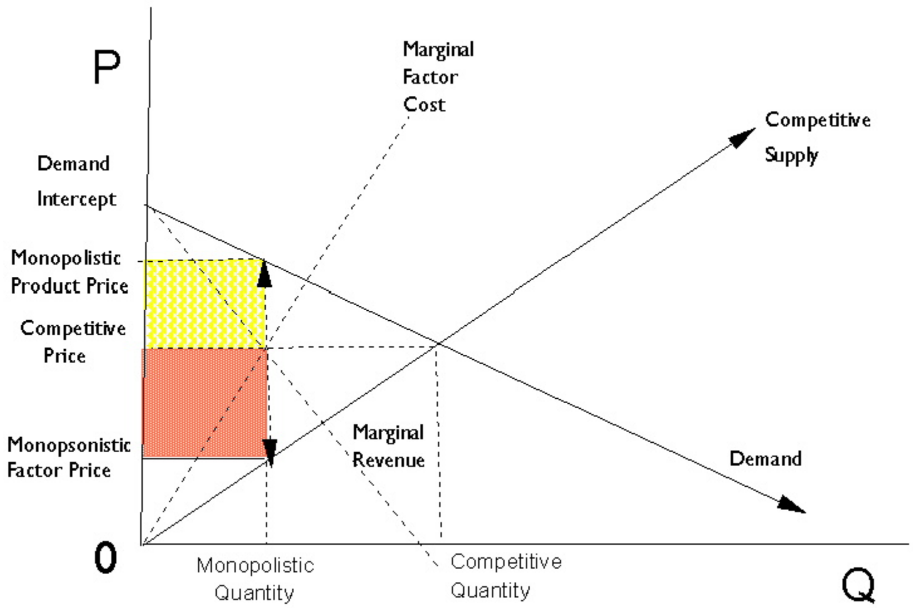
[d]Jones, Philip C., Timothy J. Lowe, and Rodney D. Traub (2002). Matching supply and demand: the value of a second chance in producing seed corn. *Review of Agricultural* Economics, 24(1): 222 - 238.

[e]Adjustment based on average yield per acre.

[f]Total variable costs are based on the costs of producing conventional corn adjusted for high oil corn.

[g]Average yield are based on a 3% yield drag from conventional corn.

Figure 1: Competitive Equilibrium, Monopolistic and Monopsonistic Rents



incurring marginal costs equal to the cost of factors necessary to produce that level of output. Monopsonistic rents, the lower shaded area, arise because a single buyer, say of a factor, need only pay the supply price of the factor while the net value of the factor to the firm is determined by the intersection of the marginal factor cost with marginal revenue. Any firm in the industry that has the market power to control the quantity supplied or set the price at which it can be sold can capture either or both types of rents, if it holds a position in more than one stage.

Which of these three alternative strategies is best depends on many considerations. Possible advantages of each strategy include:

- Licensing the technology widely under perfect competition, where the technology fee is set at the marginal cost attempts to gain largest market share. If the possibilities are favorable for widespread adoption and forging a commanding market share, or creating a strong demand for follow-on goods and services (such as printer cartridges for inkjet printers) this strategy may be the preferred one.

- Monopolistic licensing, setting the technology fee at the rent maximizing level, attempts to recover sunk costs from licensing revenues. If most costs are sunk costs, maximization of licensing revenues, such as narrowly licensing the intellectual property to independent seed companies may be an appropriate strategy.
- Monopolistic supplying of the product, at the rent maximizing level of production, attempts to cover all variable costs while maximizing residual rents to recover sunk costs. If most costs are variable, such as in operating an in-house seed company, maximization of residual rents may be the appropriate strategy and model.

In our model we compare two pure strategies: (1) monopolistic licensing of the high-oil gene to independent seed companies and (2) monopolistic supplying of high-oil seed, with (3) a base strategy of perfectly competitive licensing high-oil gene with a $20 technology fee. We further compare two cases: (2a) inelastic demand for the HOC trait with (2b) elastic demand for the HOC trait.

The High Oil Corn EDMP Model

Our EDMP model incorporates the above economic structure into a two industry, multi-stage quadratic programming model representing the HOC and conventional corn industries as they were in 1999.

Model Tableaux

The quadratic programming model tableau and solutions for the base case and the two scenario cases are shown in Table 2. This formulation models the derived demands for HOC gene and seed which result from the hedonic demand for the HOC trait, assuming services of all intermediate stages are perfectly competitively supplied. Processes (columns) represent: (1) supplying the high-oil corn gene, (2) producing and distributing high-oil corn seed, (3) producing and distributing conventional corn seed, (4) growing high-oil corn, (5) growing conventional corn, (6) a hedonic demand for the high-oil trait enhancing conventional corn demands (7) domestic demand for conventional corn, a portion of which is enhanced with the high oil trait, and (8) export demand for conventional corn, a portion of which is enhanced with the high-oil trait. All constraints are less than or equal to (LE), allowing intermediate products to be allocated to slack if their price falls below their average variable costs. The Objective Function to be maximized in the base case and two scenarios cases, differentiated by the assumed elasticity of demand for the HOC trait, consists of a vector of Intercepts and a Diagonal of the Hessian matrix. Finally, the Right Hand Side column is all zeros, indicating supply and demand market-clearing within the model. The entries in the Diagonal of Hessian row are the slopes of the particular supply and demand functions, defined as the product of the reciprocal of the elasticity times the ratio of base price to base quantity, adjusted by a multiplicative calibration constant. The Intercepts row contains the intercepts of the supply and demand functions, which are initially estimated as the product of the Hessian element times the base quantity plus the base price of that product. The method of calibration creates a set of linear functions that reproduce exactly the quantities, prices, and elasticities of the base period. The calibration constant for the Hessian element is found by additively changing the intercepts until both the base period

Table 2: High-Oil Corn Model Tableaux and Solutions: Competitive Licensing (Base), Monopolistic Licensing, Inelastic Trait Demand (Scenario 1), and Monopolistic Lice
Elastic Trait Demand (Scenario 2)

	Production Activity -->	License High-Oil Intellectual Property	Produce & Distribute High-Oil Seed	Produce & Distribute Conventional Seed	Grow High-Oil Corn	Grow Conventional Corn
	Units -- >	(1000 units seed)	(1000 units seed)	(1000 units seed)	(1000 acres)	(1000 acres)
OBJECTIVE FUNCTION						
Scenario 2 Intercepts		24.620	78.750	72.000	-223.999	311.281
Scenario 1 Intercepts		26.750	78.750	72.000	-223.999	311.281
Base Intercepts		26.750	78.750	74.300	-223.999	311.281
Scenario 2 Diagonal of Hessian		-0.293	-0.878	-0.005	0.000	-0.007
Scenario 1 Diagonal of Hessian		-0.379	-1.138	-0.005	0.000	-0.007
Base Diagonal of Hessian		-0.108	-0.325	-0.005	0.000	-0.007
CONSTRAINTS						
High-Oil GeneTransfer	(1000 units seed)	-1.000	1.000			
High Oil Seed Transfer	(1000 units seed)		-1.000		0.388	
Conventional Seed Transfer	(1000 units seed)			-1.000		0.364
High Oil Corn Transfer	(1000 bushels)				-129.790	
Conventional Corn Transfer	(1000 bushels)					-133.800
SOLUTIONS						
Scenario 2 Optimal Quantities	(1000 units)	162.463	162.463	25798.000	419.259	70746.000
Scenario 2 Selling Prices	(dollars/unit)	-19.996	-64.295	-60.753	-233.397	-226.023
Scenario 2 Factor Costs	(dollars/unit)	-8.393	-36.783	-60.753	-233.397	-226.023
Scenario 1 Optimal Quantities	(1000 units)	162.508	162.508	25855.000	419.375	70741.000
Scenario 1 Selling Prices	(dollars/unit)	-19.996	-71.933	-61.033	-235.259	-226.030
Scenario 1 Factor Costs	(dollars/unit)	-8.395	-36.786	-61.033	-235.259	-226.030
Base Equilibrium Quantities	(1000 units)	387.670	387.670	25645.000	1000.438	70502.000
Base Equilibrium Prices	(dollars/unit)	-19.996	-59.987	-60.001	-230.996	-221.760

	Demand Activity -->	High-Oil Trait Hedonic Demand	Conventional Corn Domestic Demand	Conventional Corn Export Demand	_TYPE_	RHS
	Units -- >	(million bushels)	(million bushels)	(million bushels)		
OBJECTIVE FUNCTION						
Scenario 2 Intercepts		300.000	7786.667	3742.222		
Scenario 1 Intercepts		592.265	7786.667	3742.222		
Base Intercepts		592.265	7786.667	3742.222		
Scenario 2 Diagonal of Hessian		-0.770	-0.801	-1.014		
Scenario 1 Diagonal of Hessian		-3.022	-0.801	-1.014		
Base Diagonal of Hessian		-3.022	-0.801	-1.014		
CONSTRAINTS						
High-Oil GeneTransfer	(1000 units seed)				LE	0
High Oil Seed Transfer	(1000 units seed)				LE	0
Conventional Seed Transfer	(1000 units seed)				LE	0
High Oil Corn Transfer	(1000 bushels)	1000.000			LE	0
Conventional Corn Transfer	(1000 bushels)	-1000.000	1000.000	1000.000	LE	0
SOLUTIONS						
Scenario 2 Optimal Quantities	(million bushels)	54.416	7570.144	1994.368		
Scenario 2 Selling Prices	(dollars/thousand bushels)	258.077	1819.770	1819.770		
Scenario 2 Factor Costs	(dollars/thousand bushels)	258.077	1819.770	1819.770	$25.81	Scenario 2 Tech Fee
Scenario 1 Optimal Quantities	(million bushels)	54.431	7570.099	1994.534		
Scenario 1 Selling Prices	(dollars/thousand bushels)	427.771	1819.331	1819.331		
Scenario 1 Factor Costs	(dollars/thousand bushels)	427.771	1819.331	1819.331	$42.80	Scenario 1 Tech Fee
Base Equilibrium Quantities	(million bushels)	129.731	7569.626	1994.160		
Base Equilibrium Prices	(dollars/thousand bushels)	200.206	1819.711	1819.711	$20.00	Base Tech Fee

quantities and the base period prices are matched to the desired accuracy for all activities. The calibration factor, determined as the ratio of the adjusted intercept values to the original intercept values, is applied to the Hessian element and the intercept is returned to its original value. The point of maximum rent extraction in each scenario is found by iteratively increasing the Hessian element of the stages controlled by the monopolist until the sum of captured rents is maximized. The scenarios represent alternative supply strategies by the IPR owning stage and alternative configurations of the elasticity of demand for the HOC trait in the final product.

Results

In scenarios comparing the strategies of monopolistic licensing strategy with monopolistic seed production we found that both led to identical solutions and identical sums of rent extraction over the gene supply and seed supply stages. Accordingly, we defined the scenarios to compare inelastic HOC trait demand (Scenario 1, strategy 2a) with elastic HOC trait demand (Scenario 2, strategy 2b) in Table 2. The relative magnitudes of rents extracted in monopolistic gene supply versus monopolistic seed supply are then determined by the source of the rents—revenue increases or factor savings. The Scenario 1 elasticity of hedonic demand for the HOC trait is - 0.5096, the weighted average of the domestic and export elasticities for conventional corn. In Scenario 2 this elasticity is set at -2.0. The elasticity of IPR (gene) supply for all three scenarios is assumed to be 1.0.

The major differences between the monopolistic scenarios and the perfectly competitive scenario lie in the factor savings from producing significantly less output. Monopolistic throughput, whether measured in acres or production of HOC, is cut to 42 percent of the base quantity. The optimal technology fee and the price premium for HOC react in the opposite direction from quantities, increasing by 113 percent of the base fee in the inelastic demand case and 29 percent in the elastic demand case. The conventional corn seed industry expands production to substitute for the reduced HOC seed production.

Table 3 lists the gross revenues, gross factor costs, and residual rents by stage for the base and monopolistic scenarios. The revenue from perfectly competitive licensing of the technology at the $20 base technology fee, $7.753 million, is actually higher than the maximum rents that can be extracted in the inelastic trait demand case ($7.597 million). The maximum rent is composed of $1.885 million monopolistic rent from reduced technology stages factor costs, $3.770 million monopsonistic rent from reduced seed stage factor costs, and $1.941 million monopolistic rent from increased seed selling prices.

There are strong incentives for the IPR supplier stage to also control the seed supply stages. The reduced seed production costs and revenues from increased seed prices can only be extracted by the IPR supplier if it integrates into the seed supply stage. As much as 75 percent of total rents arise in that stage. The optimal technology fee in the inelastic trait demand case is $42.80, implying a monopolistic break-even premium of $0.43 per bushel for HOC, compared to a break-even competitive premium of $0.20 per bushel.

In the elastic trait demand case, the maximum rent extraction is the same as the inelastic case for gene and seed factor cost savings, but monopolistic rents from increase seed selling prices drop to $0.700 million for a total maximum rent of $6.355 million. The optimal technology fee is $25.81 and a break-even premium is $0.26 per bushel of HOC. Again, there are strong incentives for the IPR supplier to integrate into the seed supply stage, although less than in the inelastic trait demand case.

Conclusions

The two strongest conclusions are that IPR firms have strong incentives to acquire seed supplying companies because the bulk of captured rents arise through factor savings in the seed supplying stage, and that the more inelastic the trait demand, the larger the rents that can be extracted through increased seed prices. However, to capture the monopolistic and monopsonistic rents requires massive changes in prices and quantities, which greatly diminish the size and gross revenue of the firm,

Given that there may be little monetary advantage to employing the monopolistic strategies in the high-oil corn industry -- the maximum monopolistic rent extraction is roughly equal to the purely competitive gross revenue -- other goals of the IPR firm may take precedence in determining which strategies to pursue. If preserving or maximizing firm size or market share are significant goals, then monopolistic strategies are clearly contraindicated. If there are limited opportunities for utilizing freed-up factors, or low opportunity costs for them, then the purely competitive strategy may be superior. If production opportunities are abundant for released factors, or their opportunity costs are high, then monopolistic strategies may be superior.

The EDMP methods show considerable promise for analysis of market power relationships and strategies in multi-stage industries. Among there most important attributes of the EDMP methods for such analyses are:

- Allowing conceptually correct modeling and efficient solution of models.
- Endogenizing prices and quantities at all stages of the supply chain.
- Allowing gradual quantity responses to changes in prices.
- Assuring feasibility and optimality of base and scenario solutions.

Table 3: Gross Revenues, Gross Costs and Residual Rents by Stage, High-Oil Corn EDMP Model

Stage -->	Licensing High-Oil Technology	High-Oil Seed Production/Distribution	Conventional Seed Production/Distribution	High-Oil Corn Production	Conventional Corn Production	High-Oil Trait Demand	Conventional Corn Domestic Demand	Conventional Corn Export Demand
Base: Perfectly Competitive Licensing or Seed Production, Inelastic or Elastic Trait Demand, $20 Technology Fee								
				(million dollars)				
Stage Gross Revenue	7.753	23.260	1,538.721	231.097	15,634.524	25.973	13,774.533	3,628.795
Stage Gross Costs	7.753	23.260	1,538.721	231.097	15,634.524	25.973	13,774.533	3,628.795
Stage Residual Rents	0	0	0	0	0	0	0	0
Total Residual Rents, All Stages	0							
Technology Fee/bag	$20.00		Break-even Premium/bu	$0.20				
Scenario 1: Monopolistic Licensing or Seed Production, Inelastic Trait Demand								
Stage Gross Revenue	3.250	11.690	1,577.998	98.662	15,989.087	23.284	13,772.522	3,628.718
Stage Gross Costs	1.364	5.978	1,577.998	98.662	15,989.087	23.284	13,772.522	3,628.718
Stage Residual Rents	1.885	5.712	0.000	0.000	0.000	0.000	0.000	0.000
Revenue Change From Base	-4.504	-11.570	39.278	-132.435	354.563	-2.689	-2.011	-0.077
Total Residual Rents, All Stages	$7.597	of which $1.885 is from reduced technology stage costs, $3.770 is from reduced seed production costs, and $1.941 is from increased seed prices.						
Optimal Technology Fee/ bag	$42.78		Break-even Premium/bu	$0.43				
Scenario 2: Monopolistic Licensing or Seed Production, Elastic Trait Demand								
Stage Gross Revenue	3.249	10.446	1,567.295	98.093	15,990.711	14.043	13,775.921	3,629.291
Stage Gross Costs	1.364	5.976	1,567.295	98.093	15,990.711	14.043	13,775.921	3,629.291
Stage Residual Rents	1.885	4.470	0.000	0.000	0.000	0.000	0.000	0.000
Revenue Change From Base	-4.505	-12.815	28.574	-133.004	356.188	-11.930	1.388	0.496
Total Residual Rents, All Stages	$6.355	of which $1.885 is from reduced technology stage costs, $3.770 is from reduced seed production costs, and $0.700 is from increased seed prices.						
Optimal Technology Fee/ bag	$25.81		Break-even Premium/bu	$0.26				

- Allowing different degrees of market power at different stages of the industry – from no market power to full monopoly power.
- Allowing analysis of alternative market power strategies by different stages of the supply chain.
- Allowing analysis of strategies for firms with multiple product lines and/or multiple markets.

Other multi-stage industries where EDMP methods can make a contribution include: broilers, contract turkeys, contract eggs, and contract hog production, wherein a competitive grow-out stage is typically sandwiched between stages of an integrator firm with market power, or in industries such as citrus or dairy, wherein producer cooperatives may have market power in one or more stages.

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